{In Archive} Fw: West Lake OU1 SFS Draft: OSRTI/OGC/ORIA Response to PRP Comments About Radioactivity Issues
Dan Gravatt
to:
DeAndre Singletary, Cecilia Tapia
03/22/2011 11:48 AM
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Audrey Asher
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From: Dan Gravatt/R7/USEPA/US
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2 Attachments

EPA Comment 2 and Addl Comment 1 - Principal Threat Wastes_EPAResponse.doc

EPA Addl Comment 2 - RI-NRC comparison_EPAResponse.doc

DeAndre, Cecilia,

Please take a quick look at what HQ is proposing for the feedback below and let me know if you have any problems or suggestions.

Thanks,
Dan Gravatt

-----Forwarded by Dan Gravatt/R7/USEPA/US on 03/22/2011 11:46AM -----

To: Dan Gravatt/R7/USEPA/US@EPA, Audrey Asher/R7/USEPA/US@EPA
From: Rich Kapuscinski/DC/USEPA/US
Date: 03/21/2011 11:31AM
Cc: Doug Ammon/DC/USEPA/US@EPA, Helen Dawson/DC/USEPA/US@EPA, Ron Wilhelm/DC/USEPA/US@EPA, Stuart Walker/DC/USEPA/US@EPA, Charles Openchowski/DC/USEPA/US@EPA
Subject: West Lake OU1 SFS Draft: OSRTI/OGC/ORIA Response to PRP Comments About Radioactivity Issues

Our proposed response to the PRPs regarding the principal threat and NRC issues is attached. It reflects contributions from Ron Wilhelm (ORIA), Stuart Walker (OSRTI), Doug Ammon (OSRTI), Charles Openchowski (OGC) and me, as well from Region 7 regarding a substantially similar interim draft.

Rich Kapuscinski

(See attached file: EPA Comment 2 and Addl Comment 1 - Principal Threat Wastes_EPAResponse.doc) (See attached file: EPA Addl Comment 2 - RI-NRC comparison_EPAResponse.doc)

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EPA General Comment No. 2 and EPA Additional Comment No. 1 – Principal Threat Wastes Analysis

Comments

EPA General Comment No. 2 – Section 3.1 of the SFS workplan states that the SFS will include an evaluation of potential occurrences of principal threat wastes. This evaluation was not found in the SFS and must be included.

EPA Additional Comment No. 1 - The final document should include a full and accurate characterization of the radioactive and other (e.g., RCRA hazardous waste) materials. Among other things, it should address EPA's principal threat determination guidance (OSWER Directive 9380.3-06FS). Based on information and data contained in the remedial investigation (RI) report, as well as two NRC reports (1982 and 1988 described more fully in #2 below), it would be appropriate to conclude that the radioactive materials could pose "a significant risk to human health should exposure occur" because these materials have "high concentrations of toxic compounds." For example, in light of the fact that cleanup level is 5 pCi/g, it is significant that the NRC reports state that subsurface soil contamination concentrations of Ra-226 (radium) are up to 22,000 pCi per gram (1988 report at p. 9). The remedial investigation report indicates radionuclide concentrations as high as those reported by NRC.

Consistent with the statute, NCP and program guidance, principal threat waste (PTW), whether radioactive or chemical, triggers the need to evaluate treatment options (which could be added to current Section 4). Thus, the SFS needs to explain how the remedial alternatives for OU1 at this Site satisfy the preference for treatment to significantly reduce toxicity, mobility, and volume. The materials may be considered PTW in accordance with the NCP, therefore, a discussion of the treatment of PTW needs to be included. The draft report does not indicate whether any treatment, including stabilization technologies, was considered.

Discussion

Regulatory Background

The National Contingency Plan (NCP) establishes an expectation that treatment will be used to address the principal threats posed by a Site whenever practicable [section 300.430(a)(1)(iii)(A)]. EPA experience with site remediation indicates that certain source materials are best addressed through treatment (EPA, 1991a).

The concept of principal threat waste and low level threat waste as developed by EPA in the NCP is to be applied on a site-specific basis when characterizing source material (EPA, 1991a). Source material is defined as material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure (EPA, 1991a). Principal threat wastes are those source materials considered to

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be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur (EPA, 1991a). They include liquids and other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds (EPA, 1991a). No "bright line" threshold level of toxicity/risk has been established to equate to "principal threat"; however, where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally treatment alternatives should be evaluated (EPA, 1991a). Low level threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of a release (EPA, 1991a).

The identification of principal and low level threats is made on a site-specific basis (EPA, 1991a).

Proposed SFS Revisions

Subject to EPA approval of the evaluation and discussion presented above, this information will be incorporated into new section of the SFS that presents characterization of the RIM. Specifically, EPA Additional Comment No. 15 requested that a separate section devoted to the characterization of the RIM be added to the SFS report.

In addition, subject to EPA approval, evaluation of potential treatment technologies will be added to the technology screening currently included in Section 4 of the draft SFS report. Technologies to be evaluated will include those technologies applicable to solid media as identified in EPA's "Technology Reference Guide for Radioactively Contaminated Media" (EPA, 2007).

References

Auxier & Associates, 2000, Draft Baseline Risk Assessment, West Lake Landfill Operable Unit 1, April.

Engineering Management Support, Inc. (EMSI), 2006, Feasibility Study, West Lake Landfill Operable Unit – 1, Final, May, 8.

EMSI, 2005, Feasibility Study, West Lake Landfill Operable Unit – 1, Revised Draft, March, 26.

EMSI, 2004, Feasibility Study, West Lake Landfill Operable Unit – 1, Revised Draft, June, 8.

EMSI, 2002, Feasibility Study, West Lake Landfill Operable Unit – 1, Revised Draft, December 16.

EMSI, 2000a, Feasibility Study, West Lake Landfill Operable Unit – 1, Draft, February, 18.

Deleted: Determination as to whether a source material is a principal or low level threat waste should be based on the inherent toxicity as well as a consideration of the physical state of the material (e.g., liquid), the potential mobility of the waste in the particular environmental setting, and the stability and degradation products of the material. Wastes that generally will be considered to constitute principal threat wastes include, but are not limited to:¶
¶
Liquids – waste contained in drums, lagoons or tanks, free product (NAPLs) floating on or under groundwater (generally excluding ground water) containing contaminants of concern.¶
¶
Mobile source material – surface soil or subsurface soil containing high concentrations of contaminants of concern that are (or potentially are) mobile due to wind entrainment, volatilizations (e.g., VOCs), surface runoff, or sub-surface transport.¶
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Highly toxic source material – buried drummed non-liquid wastes, buried tanks containing non-liquid wastes, or soil containing significant concentrations of highly toxic materials.¶
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Wastes that generally will be considered to constitute low level threat wastes include, but are not limited to ¶
¶
Non-mobile contaminated source material of low to moderate toxicity – surface soil containing contaminants of concern that generally are relatively immobile in air or ground water (i.e., non-liquid, low volatility, low leachability contaminants such as high molecular weight compounds) in specific environmental settings.¶
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Low toxicity source material – soil and subsurface soil concentrations not greatly above reference dose levels or that present an excess cancer risk near the acceptable risk range.¶
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In some situations, site wastes will not be readily classifiable as either principal or low level threat waste, and thus no general expectations on how best to manage these source materials of moderate toxicity and mobility will necessarily apply (EPA, 1991a). In these situations wastes do not have to be characterized as either one or the other. The principal threat/low level threat waste concept and the NCP expectations were established to help streamline and focus the remedy selection process and not as a mandatory waste classification requirement (EPA, 1991a).¶
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Prior Site Determinations Regarding Principal Threat Wastes¶
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Evaluation of potential occurrences of principal threat wastes in OU-1 was performed in conjunction with the initial February 2000 draft Feasibility Study (FS) report (EMSI, 2000a) and the subsequent September 2000 evaluation of potential "hot spot" removal (EMSI, 2000b). Both of these evaluations concluded that the radiologically-impacted materials at the site were not principal threat wastes. These same evaluations were included in subsequen ... [1]

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EMSI, 2000b, Technical Memorandum: Evaluation of Potential "Hot Spot" Occurrences and Removal for Radiologically Impacted Soil, West Lake Landfill OU-1, September.

EMSI, 2000c, Remedial Investigation Report, West Lake Landfill Operable Unit 1, April.

United States Environmental Protection Agency (USEPA), 2008, Record of Decision West Lake Landfill Site, Bridgeton, Missouri, Operable Unit 1, May.

USEPA, 2007, Technology Reference Guide for Radioactively Contaminated Media, EPA 402 R-07-004, October.

USEPA, 1996, Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills, EPA 540/F-96/020, OERR Directive No. 9355.0-67FS, December.

USEPA, 1993, Presumptive Remedy for CERCLA Municipal Landfill Sites, EPA 540-F-93-035, OERR Directive No. 9355.0-49FS, September.

USEPA, 1991a, A Guide to Principal Threat and Low Level Threat Wastes, Office of Solid Waste and Emergency Response Superfund Publication 9380.3-06FS, November.

USEPA, 1991b, Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites, EPA/540/P-91/001, February.

USEPA, 1990, National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR 300, Federal Register 55:8666, March 8.

USEPA, 1989, Risk Assessment Guidance for Superfund Volume 1 Human Health Evaluation Manual (Part A) Interim Final, EPA/540/1-89/002, December.

United States Nuclear Regulatory Commission (NRC), 1988, Radioactive Material in the West Lake Landfill, NUREG-1308 Rev. 1, June.

NRC, 1982, Radiological Survey of the West Lake Landfill, St. Louis County, Missouri, NUREG/CR-2722, May.

EPA RESPONSE:

EPA does not approve of the evaluation and discussion presented above (see pages 1 through 9, under "Discussion"). The objectionable portions are shown with ~~strikeout text~~ above.

For purposes of recording that Areas 1 and 2 contain principal threat waste, EPA recommends that the following text be incorporated into the new section of the SFS that would present the characterization of the radiologically impacted materials (RIM),

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instead of the discussion and evaluation presented above on pages 1 through 9 (under "Discussion"):

> Portions of the waste mass within OU1 contain concentrations of radionuclides which are highly toxic, considering that they would present a significant risk to human health or the environment should exposure occur.

The foregoing, concise narrative emphasizes toxicity/risk characteristics of portions of the RIM, consistent with the emphasis suggested by EPA during our meeting in Kansas City in September 2010.

For purposes of evaluating principal threat waste and potential treatment options at West Lake Landfill OU1, highly toxic RIM will be considered to be material with concentrations at or exceeding 79 pCi/g of radium 226 and 228 combined, or 79 pCi/g of thorium 230 and 232 combined, or 545 pCi/g of total uranium. These concentrations are an order of magnitude higher than the respective cleanup levels (i.e., 7.9 pCi/g for radium and thorium and 54.5 pCi/g for total uranium). The cleanup level for radium and thorium is based on the UMTRCA ARAR which is associated with an excess lifetime cancer risk at 10^{-4}. The cleanup level for uranium is based on a non-cancer hazard quotient (HQ) of 1. These concentrations will help identify which waste may constitute a principal threat and, therefore, should be considered for treatment to the maximum extent practicable.

EPA concurs that potential treatment technologies should be evaluated in the SFS. This evaluation should be added to the technology screening currently included in Section 4 of the draft SFS report and should consider the expected further in-growth of radionuclides due to radioactive disequilibrium.

The presence of volumes of highly toxic wastes within the waste mass in Areas 1 and 2 and the expectation of additional in-growth of radionuclides over a prolonged duration necessitate an evaluation of treatment options as required by CERCLA. The SFS should consider options to treat all of the highly toxic RIM, as well as portions of the highly toxic RIM. This evaluation should be consistent with OSWER Directive 9380.3 and corresponding NCP language (e.g., 55 FR at 8703, March 8, 1990). To the extent that there are portions of OU1 where there are identifiable concentrations of wastes that exceed the levels described in the previous paragraph, then these areas should be analyzed separately as to the potential for treatment. For example, if there is an area of the waste that is significantly higher in concentration than these levels, which are defined as highly toxic RIM for West Lake, and these even higher concentrations are in a generally discrete and findable location, then waste treatment for that area may be practicable whereas treatment of the other volumes of highly toxic RIM might not be practicable.

The Administrative Record needs to support the analysis of what constitutes a principal threat waste, including the nature of the contamination, locations, concentration and volume, etc. The Administrative Record also needs to sufficiently support the Agency's determination that the statutory preference to treat to the maximum extent practicable has

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been addressed for wastes that exhibit high toxicity, toxicity, or volume (i.e., wastes that constitute a Principal Threat).

As noted in the NCP (300.430(f)(5)), a Record of Decision needs to make a statutory finding related to treatment "(E) How the remedy utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable..." This is based on CERCLA 121(b)(1) that states the following: "Remedial actions in which treatment which permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substance, pollutant, and contaminants is a principal element, are to be preferred over remedial actions not involving such treatment... The President shall select a remedial action that is protective of human health and the environment, that is cost effective, and that utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable."

EPA expects that treatment will be the preferred means by which to address the principal threats posed by a site, wherever practicable. Principal threats are characterized as waste that cannot be reliably controlled in place, such as liquids, highly mobile materials (e.g., solvents), and high concentrations of toxic compounds (e.g., several orders of magnitude above levels that allow for unrestricted use and unlimited exposure). (See 55 FR 8703, March 9, 1990)

The yellow-highlighted text in the discussion and evaluation presented above (pages 1 through 9, under "Discussion", with amendments shown in "track changes") may be incorporated into the revised SFS in an appropriate location.

EPA requests and expects that future revisions of the SFS be provided to us in the form of complete chapters, ideally in a sequence corresponding to the final document, as was requested during our meeting in Kansas City in September 2010.

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Determination as to whether a source material is a principal or low level threat waste should be based on the inherent toxicity as well as a consideration of the physical state of the material (e.g., liquid), the potential mobility of the waste in the particular environmental setting, and the stability and degradation products of the material. Wastes that generally will be considered to constitute principal threat wastes include, but are not limited to:

Liquids – waste contained in drums, lagoons or tanks, free product (NAPLs) floating on or under groundwater (generally excluding ground water) containing contaminants of concern.

Mobile source material – surface soil or subsurface soil containing high concentrations of contaminants of concern that are (or potentially are) mobile due to wind entrainment, volatilizations (e.g., VOCs), surface runoff, or sub-surface transport.

Highly toxic source material – buried drummed non-liquid wastes, buried tanks containing non-liquid wastes, or soil containing significant concentrations of highly toxic materials.

Wastes that generally will be considered to constitute low level threat wastes include, but are not limited to

Non-mobile contaminated source material of low to moderate toxicity – surface soil containing contaminants of concern that generally are relatively immobile in air or ground water (i.e., non-liquid, low volatility, low leachability contaminants such as high molecular weight compounds) in specific environmental settings.

Low toxicity source material – soil and subsurface soil concentrations not greatly above reference dose levels or that present an excess cancer risk near the acceptable risk range.

In some situations, site wastes will not be readily classifiable as either principal or low level threat waste, and thus no general expectations on how best to manage these source materials of moderate toxicity and mobility will necessarily apply (EPA, 1991a). In these situations wastes do not have to be characterized as either one or the other. The principal threat/low level threat waste concept and the NCP expectations were established to help streamline and focus the remedy selection process and not as a mandatory waste classification requirement (EPA, 1991a).

Prior Site Determinations Regarding Principal Threat Wastes

Evaluation of potential occurrences of principal threat wastes in OU-1 was performed in conjunction with the initial February 2000 draft Feasibility Study (FS) report (EMSI, 2000a) and the subsequent September 2000 evaluation of potential "hot spot" removal (EMSI, 2000b). Both of these evaluations concluded that the radiologically-impacted materials at the site were not principal threat wastes. These same evaluations were included in subsequent drafts of the FS report (EMSI, 2002, 2004, and 2005) and in the final FS report (EMSI, 2006) that was accepted by EPA and used as a basis for development of the Proposed Plan and Record of Decision.

EPA subsequently determined in the Record of Decision that no principal threat wastes are present at the site (EPA, 2008). EPA found that the hazardous substances present in OU-1, including the radionuclides, are dispersed in a heterogeneous mix of municipal solid wastes. The preamble to the NCP identifies municipal landfills as a type of site where treatment of waste may be impracticable because of the size and heterogeneity of the contents (55 FR 8704). Waste in CERCLA municipal landfills usually is present in large volumes and is a heterogeneous mixture of municipal waste frequently co-disposed with industrial and/or hazardous waste. EPA has established source containment as the presumptive remedy for CERCLA municipal landfill sites. In appropriate circumstances, excavation and/or treatment of "hot spots" should be evaluated. Such an evaluation was previously performed for OU-1 and is presented in the original Feasibility Study (FS) report.

Additional Evaluations of Potential Principal Threat Wastes

In response to EPA's comments, the potential for occurrence of principal threat wastes (PTW) was re-evaluated. The factors listed in EPA's 1991 guidance on PTW, as described above, were used to evaluate the potential for occurrence of PTW in OU-1 at West Lake Landfill.

Liquid – OU-1 contains municipal solid wastes including household wastes, construction and demolition debris, and possibly industrial wastes. Reportedly, 8,700 tons of leached barium sulfate residue were mixed with 39,000 tons of soil and transported to the site for use as daily and intermediate cover in the solid waste landfill operation. This material was a solid and there is no information indicating or suggesting that any radiological material was disposed in liquid form, was containerized, or otherwise may occur as a liquid waste.

Mobility of Source Material – The groundwater monitoring data show no evidence of significant leaching and migration of radionuclides from Areas 1 and 2. The vast majority of the groundwater monitoring results are consistent with background concentrations. Only two wells exhibited a total radium concentration slightly above the EPA drinking water maximum contaminant level (MCL) of 5 pCi/l with values ranging from 5.74 to 6.33 pCi/l. These occurrences are spatially isolated and not indicative of the presence of a plume or definable area of groundwater contamination. Perched water samples obtained from within the landfilled waste were sampled and analyzed and were not found to contain elevated concentrations of radionuclides. This is the case even though the waste materials have been in place with nearly flat surface grades and without a landfill cover for over 30 years. In other words, significant leaching and migration of radionuclides to perched water or groundwater have not occurred despite the fact that the landfill wastes have been exposed to worst-case leaching conditions (i.e., maximum precipitation and surface water infiltration due to nearly flat surface grades and absence of a landfill cover) over a period of decades.

The potential for future leaching to groundwater was also evaluated during the Remedial Investigation (RI) (EMSI, 2000c). A dominant factor influencing the transport and environmental fate of contaminants is the sorption-desorption process. Desorption or leaching is the process whereby molecules attached to the solid phase (in this case soil) are mobilized into the dissolved phase in water. Sorption is the process by which the molecules become or remain attached to the solid phase (soil). The degree to which a molecule is sorbed onto the soil or is

leached into water is characterized by the distribution coefficient, a factor that relates the concentration sorbed onto a solid with the concentration in water in contact with that solid. The distribution coefficient values for radionuclides are relatively high, consistent with the tendency of radionuclides to remain in the soil or sediment phases rather than leaching into the water phase. Partitioning calculations using site data were presented in the RI. The calculated radionuclide concentrations based on the distribution coefficient are consistent with the groundwater sampling data collected during the RI. These calculations along with the results of the groundwater monitoring support the conclusion that even in the absence of an infiltration barrier (e.g, landfill cover), impacts to groundwater over time are likely to be low.

Radionuclides generally have relatively low solubilities in water and instead display an affinity to adsorb onto the soil matrix. Uranium does possess a greater solubility than that of the other radionuclides. Uranium has been detected in groundwater samples obtained from Site monitoring wells at levels of approximately 5 pCi/l or less. Uranium has been detected in upgradient, background wells at levels up to approximately 2 pCi/l. EPA has established an MCL of 30 ug/l (approximately 30 pCi/l) for uranium in public drinking water supplies. The uranium in the barium sulfate residue is insoluble in water; that is the uranium cannot be leached from the barium sulfate using water alone. Consequently, significant levels of uranium are not expected to occur and have not been found in groundwater at the site.

Radionuclides can be transported to the atmosphere either as a gas in the case of radon or as fugitive dust in the case of other radionuclides. Both potential pathways were evaluated in the RI/FS based on site-specific data. Radon flux measurements were made at 54 locations in Areas 1 and 2. Although several locations reported high radon flux measurements, the average radon flux across Areas 1 and 2 was relatively low. The average radon flux from Areas 1 and 2 under current conditions with no landfill cap in place is less than the standard (20 pCi/m^2s) that is considered safe for tailings piles at uranium mill tailings sites (40 CFR 192.02(b)). Release of radon is likely an exposure concern only in the hypothetical event someone occupied a building or structure on or immediately adjacent to Areas 1 and 2. Existing land-use covenants prohibit construction of buildings on Areas 1 and 2. The potential for radon emissions is easily mitigated with containment via a landfill cover.

During the RI fugitive dust monitoring was performed at locations that contain the highest radionuclide concentrations in surface soil samples. Analysis of these samples indicated that fugitive dust is not a significant pathway for radionuclide migration from Areas 1 and 2. Fugitive dust is not considered a significant pathway for radionuclide migration under current conditions, primarily because the surfaces of Areas 1 and 2 are, for the most part, vegetated. The potential for fugitive dust migration is easily mitigated with containment via a landfill cover.

Toxicity of the Source Material - There is no evidence of buried drums of non-liquid wastes or buried tanks containing non-liquid wastes in the waste materials in West Lake Landfill Areas 1 and 2. However, the radiologically contaminated soils mixed with the solid waste contain significant concentrations of naturally occurring radionuclides from the uranium (U-238), thorium (Th-232) and actinium (U-235) decay series.

As part of the RI, extensive surface and subsurface investigations were performed. Investigations included overland gamma surveys and an extensive soil boring and soil sampling and analysis program to characterize the distribution and extent of radiological and non-radiological constituents. Twenty borings were completed in Area 1 and forty borings were completed in Area 2. Isotopic analysis was performed on soil samples that were collected at various depth intervals that generally correlated with elevated gamma readings as measured in downhole radiological surveys. Soil analytical results were compared to reference levels derived from the soil cleanup standards in 40 CFR 192 (5 pCi/g surface and 15 pCi/g subsurface for Ra_{226} or Ra_{228}). Maximum concentrations of some radionuclides were found to be high relative to the reference levels used in the RI (e.g., Th_{230} greater than 10,000 pCi/g, Ra_{226} greater than 1,000 pCi/g and U_{238} greater than 200 pCi/g). The investigations also determined that the distribution of radionuclide occurrences is quite variable and the numbers of detections in this range are small. The soil sample analytical results indicate that the average concentrations of radionuclides greater than 5 pCi/g plus background (e.g., 94 pCi/g for Th_{230}, 33 pCi/g for Ra_{226} and 16 pCi/g for U_{238}) in Areas 1 and 2 are generally more in range with reference levels.

A prior investigation conducted by the Nuclear Regulatory Commission (NRC) drilled and logged 39 soil borings including 10 borings in Area 1 and 29 borings in Area 2 (NRC, 1982). Based on its investigations, the NRC reported the presence of Ra_{226} levels of up to 22,000 pCi/g (NRC, 1982 and 1988). As discussed in the response to EPA Additional Comment No. 2, the location of the NRC soil boring (boring no. 1) from which the 22,000 pCi/g value was reportedly found could not be determined from the information provided in the NRC reports. Furthermore, the NRC studies did not perform radiochemical analyses of soil samples to determine the levels of Ra_{226} or other radionuclides present in Areas 1 and 2. The NRC study logged representative boreholes using an in situ gamma measurement system consisting of an intrinsic germanium (IG) detector coupled to a multichannel analyzer to perform quantitative and qualitative field analyses. Finally, review of the NRC report indicates that problems were encountered in the use of this system. Specifically, the 1982 NRC report states "The field use of this system was somewhat limited by initial failure due to high humidity effects on the pre-amp components and thermal insulation of the detector housing. These problems were partially corrected by sealing the detector in an outer container and allowing dry air to flow through the container." Data generated by such field analyses are not of the same quality as data generated by radiochemical analyses at an offsite, EPA-certified analytical laboratory. Results of the RI sampling and offsite laboratory analyses of soil samples failed to re-produce the Ra_{226} levels reported in the NRC report. A total of 48 and 73 soil samples were obtained from Area 1 and 2, respectively as part of the RI investigations (not counting field or laboratory duplicate samples or background samples). The highest Ra_{226} level found in all of the RI soil samples was 3,720 pCi/g. The next highest samples contained Ra_{226} levels of 3,060 pCi/g (duplicate sample reportedly contained 1,260 pCi/g), 2,970 pCi/g (duplicate sample reportedly contained 3,140 pCi/g), and 2,280 pCi/g. The vast majority of the samples contained Ra_{226} levels in the range of less than 1 pCi/g to less than 20 pCi/g. Consequently, it is inappropriate to base an analysis of the toxicity of the source material on the results of unconfirmed field analyses obtained by the NRC study.

It is also important to factor in risk analysis since the health threats posed by these radionuclides are a function not only of the concentration of the radionuclides but also the manner in which someone might become exposed, and the period of time over which someone is exposed. The

radionuclides came from processed ore residues, and the ratio of Th-230 to Ra-226 is much greater than would be the case if these radionuclides were in equilibrium. Therefore, the calculations of potential risk presented in the baseline risk assessment were adjusted for ingrowth of Ra-226 and its eight daughters from decay of Th-230 over a 1,000 year study period.

The Baseline Risk Assessment (BRA) (Auxier & Associates, 2000) looked at potential exposure scenarios based on reasonably anticipated land use including groundskeepers and other workers using Areas 1 and 2 for storage or other ancillary purposes. Under the assumption that radionuclides remain at or near the ground surface, some exposure to these workers would occur. The assessment used standard exposure factors and toxicity values to estimate the health risks to these hypothetical workers. Exposure frequencies and routes of exposure vary depending on the nature of the job. Exposure duration, or the time a worker remains in the job, was assumed to be 6.6 years.

Consistent with EPA risk assessment guidance (EPA, 1989), the assessment of radiological health risks was limited to carcinogenic effects. Carcinogenicity is assumed to be the limiting deleterious effect from low radiation doses. The calculated risks are expressed in terms of increased lifetime cancer risk to the exposed individual. Under most scenarios, the calculated cancer risks are within EPA's acceptable risk range defined as 1×10^{-4} or 1 in 10,000. However, under two future receptor scenarios, the grounds keeper and the storage yard worker, the individual lifetime cancer risk was calculated to be 2×10^{-4} and 4×10^{-4} respectively, slightly exceeding the acceptable risk range. These calculated risks were based on calculated future (1,000 year) radium concentrations of 3,224 and 3,653 pCi/g for Areas 1 and 2 respectively. The calculated risks do not meet the 10^{-3} risk level criteria set forth in EPA's 1991 guidance for identification of principal threat wastes. It would take projected future concentrations approximately ten times greater than these to result in calculated risk levels slightly greater than 10^{-3} risk level. The potential risks can be managed by preventing direct contact with the waste materials through construction of a new landfill cover and implementation of additional institutional controls on future land uses.

Can the waste material be reliably contained - At the West Lake Landfill Site OU-1, the municipal wastes were placed above grade. The surface elevation of the site at OU-1 is 20 to 30 feet or more above the level of the historic flood plain. Most of the radiologically contaminated materials occur in the upper half of the waste fill. There is no means for water to contact the radiologically contaminated materials except through surface infiltration.

Capping through the use of engineered covers is a well understood and routinely applied technology that forms a barrier between the contaminated material and the surface. Multi-layer, natural material cover systems are effectively used to mitigate the release of radon gas, minimize water infiltration, and remain effective for long periods of time (EPA 2007).

The engineered landfill cover included in the ROD-selected remedy will be designed to prevent surface water from contacting and potentially leaching the waste material. Surface grading and run-on/run-off controls would be used to shed surface water and divert it from the disposal areas. A low permeability layer would also be incorporated to further mitigate the potential for surface

water infiltration. Installation of the cover system would reduce or eliminate any perched water that currently exist within the landfill.

When caps are used to contain radium contaminated materials they are typically designed to confine gaseous radon until it has essentially decayed. Such systems are used to contain long-lived radionulides at large uranium mill tailing sites where radon generation is a much larger concern than at the West Lake Site due to the vast amounts of tailings involved. Since radon decays rather rapidly (Ra-222 has a half life of 3.8 days), vertically migrating gas only needs to be detained for a relatively short period of time for the radon to decay. The engineered landfill cover included in the ROD-selected remedy will be designed and constructed with sufficient thickness of natural materials to attenuate radon. Under the selected remedy, radon measurements at the surface of the cap should be indistinguishable from background.

Conclusion - The radiological source material in West Lake Landfill OU-1 is not liquid; it is relatively immobile in this environmental setting; it is of low to moderate toxicity, and; it can be reliably contained. Based on the considerations provided in the EPA guidance (EPA, 1991), the radiological source materials at the site are more similar to low level threat wastes than principal threat wastes.

Treatment - Consistent with the NCP, EPA's expectation is that source containment technologies generally would be appropriate for municipal landfill waste because the volume and heterogeneity of the waste material generally make treatment impracticable.
This expectation is also established by the EPA directive – "Presumptive Remedy for CERCLA Municipal Landfill Sites" (EPA, 1993) and EPA's Guidance for Performance of RI/FS at CERCLA Municipal Landfill Sites (EPA, 1991b).

In a subsequent directive "Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills" (EPA, 1996), EPA provided guidance on the application of the presumptive approach to military landfills. Generally, the presumptive approach is appropriate for military landfills that are similar to municipal landfills but may also have low-hazard military specific waste, such as low-level radioactive wastes, which are generally no more hazardous than some of the industrial or hazardous wastes frequently found in CERCLA municipal landfills. In many cases, these hazardous chemical substances (e.g., industrial wastes containing chlorinated solvents) are much more toxic and more mobile in the environment than the radionuclides found in Areas 1 and 2.

Consistent with the expectations in the NCP and related guidance for landfills, treatment to reduce toxicity, mobility, or volume is not considered practicable. Most contaminants within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout the overall matrix of municipal refuse and construction and demolition debris.
The large scale and heterogeneous nature of the waste materials make excavation of the radiologically impacted materials for possible ex situ treatment techniques impracticable.
In addition, there are no in-situ treatment technologies that can be applied to this circumstance.
The ROD-selected remedy represents the maximum extent to which permanent solutions and treatment are practicable.

Hot spots - According to the presumptive remedy guidance for CERCLA Municipal Landfills (EPA, 1993), the decision to characterize and/or treat hot spots is a site-specific judgment that should be based on a standard set of considerations. These considerations are highlighted below. As specified in the presumptive remedy guidance document, the overriding question is whether the combination of characteristics is such that leaving the waste in place would threaten the reliability of the containment system.

If all of the following questions can be answered in the affirmative, it is likely that characterization and/or treatment of hot spots is warranted:

Does evidence exist to indicate the presence and approximate location of waste?

Is the hot spot known to be principal threat waste?

Is the waste in a discrete accessible part of the landfill?

Is the hot spot known to be large enough that its remediation will reduce the overall threat posed by the site but small enough that it is reasonable to consider removal (e.g., 100,000 cubic yards or less)?

Based on extensive field investigation and evaluation, the nature and location of the radiological source material is well known. However, the answer to all other questions is negative. As discussed above, the radiological source material is more similar to low level threat waste than principal threat waste and can be reliably contained. Moreover, the radionuclides are dispersed within soil material that is further dispersed throughout the overall, heterogeneous matrix of municipal refuse and construction and demolition debris. Analysis of the RI boring data indicates that the vertical distribution of the radionuclides is highly variable and irregular, even over short horizontal distances. This sort of distribution is not consistent with the condition that the waste be present in a discrete and accessible location. The volume of material that would need to be removed depends on whether sorting of the waste material is considered practical or economical. In any event, the volume of material that would need to be removed to recover a majority of the radiological contamination is several times larger than 100,000 cubic yards. As such, there are no hot spots in Areas 1 and 2 requiring characterization and treatment.

EPA Additional Comment No. 2 – Reconciliation of NRC and RI Findings

Comment

The final document's full and accurate characterization of the radioactive materials should explicitly reconcile the data and findings of the RI with the data, primary findings, and conclusions of a radiological survey conducted by Radiation Management Corporation (RMC) for NRC in 1980-1981 (and published in 1982), and the 1988 NRC Summary Report, including:

- Radioactive contaminants are in two areas (which were subsequently designated as Radiological Disposal Areas 1 and 2) (at page 20 of RMC report). Almost all of the radioactivity is from uranium (U-238 and U-235) and its decay products (at page 20). Radioactivity is dominated by thorium-230 and radium-226.

- In addition, " . . . the radioactive decay of the Th-230 will increase the concentration of its decay product Ra-226 until these two radionuclides are again in equilibrium. . . .the Ra-226 activity will increase by a factor of five over the next 100 years, by a factor of nine 200 years from now, and by a factor of thirty-five 1000 years from now. . . Therefore, the long-term Ra-226 concentration will exceed the Option 4 criteria. Under these conditions, onsite disposal, if possible, will likely require moving the material to a carefully designed and constructed 'disposal cell.'" (1988 report at p. 13). And in the Summary section, the 1988 report (at p. 15) states: "A dominant factor for the future is that the average activity concentration of Th-230 is much larger than that of its decay product Ra-226, indicating a *significant increase in the radiological hazards in the years and centuries to come.*" (emphasis added).

- Subsurface deposits extend beyond areas where surface radiation measurements exceed [NRC] action criteria.

- "In general, the subsurface contamination appears to be a continuous single layer, ranging from two to fifteen feet thick, located between the elevations of 455 feet and 480 feet and covering 16 acres total area." (at page 15 and similar language at page 21); "a fairly continuous, thin layer of contamination, as indicated by survey results" (1982 report at p. 16); "The contaminated soil forms a more or less continuous layer from 2 to 15 feet in thickness (1988 report p. 5); "the waste was covered with only about 3 feet of soil." (1988 report at p. 1).

- These data are generally "... consistent with the operating history of the site, which suggests that the contaminated materials was moved onto the Site within a few days time, and spread as cover over fill material." (at page 16 and similar language at page 20)

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Discussion

Data and information contained in the two NRC reports (NRC 1982 and 1988) as well as the data and information contained in the RMC report (RMC, 1980) were used and considered during preparation of the RI report for OU-1. Specifically, the estimated radionuclide activity levels calculated by RMC/NRC based on the results of the downhole gamma logging were included and used as part of the characterization of the nature and extent of contamination presented in the RI. Similarly, the locations and areal extents of contamination presented in the NRC/RMC reports were reviewed and considered as part of the evaluation of the extent of contamination presented in the RI report. In response to the comment on the SFS, this information was again reviewed with respect to the nature and extent of the radionuclide occurrences within OU-1 and incorporated into a summary discussion of the nature and extent of radiological contamination, presented below, that will be included in the revised SFS report.

The discussions below present evaluations of the NRC and RI investigation results relative to the five bulleted items listed in EPA's Additional Comment No. 2. Overall, both investigations identified approximately the same two areas (Areas 1 and 2) where radiologically impacted materials (RIM) are present at the West Lake Landfill. Both studies found that the radioactivity at the Site results from occurrences of uranium and its decay products and is dominated by thorium-230 and radium-226. Both studies determined that the levels of radium-226 at the site were not in equilibrium with the levels of thorium-230 and consequently, the levels of radium-226 are anticipated to increase as a result of decay of throrium-230 over time. Both studies determined that the subsurface occurrences of RIM extend beyond the limits of the surface occurrences of RIM.

Locations and extents of radionuclide occurrences

Radionuclides have been identified as being present in two distinct and separate areas at the landfill. These two areas have been designated as Radiological Area 1 (Area 1) and Radiological Area 2 (Area 2) (Figure 1). Prior investigations of radionuclide occurrences at West Lake Landfill (NRC, 1982, NRC, 1988, EMSI, 2000, EMSI, 2006, and EMSI, 2010) have identified these same two areas as the locations where radionuclides are present at the Site. Area 1 encompasses an approximately 10 acre area located immediately to the southeast of the main entrance road to the West Lake Landfill property. Area 2 encompasses approximately 30 acres along the northern boundary of the West Lake Landfill property (Figure 1).

The actual extent of the radionuclide occurrences within these two areas is less than the areas initially identified as Areas 1 and 2. NRC (1988) described the extent of radiological occurrences in Area 1 and 2 as being 3 acres and 13 acres in size respectively. The RI report (EMSI, 2000), identified somewhat larger extents of radiological occurrences including 4.5 acres in Area 1 and 19.2 acres in Area 2. The results of both the NRC investigations and the RI indicated that the subsurface extent of

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radionuclide occurrences in Areas 1 and 2 is greater than the surface extent of radionuclide occurrences in these areas.

The RI also identified approximately 4.5 acres of the adjacent (northern) property (formerly the Ford property but subsequently the Buffer Zone and a portion of the Crossroad property) as potentially containing radiological occurrences in surficial soil. It should be noted that subsequent to the RI, this area was scraped and graded by the occupant of the adjacent property, with much of the surficial soil being pushed back toward the landfill. In addition, gravel cover was placed over the Crossroad portion of this area. Consequently, the current extent of radiological occurrences in this area is uncertain and therefore will be subject to additional characterization during the Remedial Design effort.

Figure 1 presents and compares the extent of RIM identified in the 1982 NRC report, the 1988 NRC report, the 2000 RI report, and the 2010 SFS report. All four reports identified the same two general areas of RIM occurrences at the site.

Thorium-230 Disequilibrium and Radium-226 In-growth

Radionuclides present in Area 1 and 2 are derived from uranium (uranium-238 [U_{238}] and uranium-235 [U_{235}]) and its decay products. The primary decay products of concern are thorium-230 (Th_{230}) and radium-226 (Ra_{226}) owing to the higher activity (concentration) levels, higher radiation levels, and/or longer half lives of these isotopes. Although the various studies of radionuclide occurrences at the West Lake Landfill may have characterized different suites of radionuclides, all of the studies evaluated the nature and extent of Th_{230} and Ra_{226} and all identified the presence of these isotopes as the primary radionuclides of concern at the Site.

Results of all of the investigations of the site have identified that the activity level of Th_{230} exceeds, and is not in equilibrium with that of the other radinuclides, notably, Ra_{226}. Consequently, as a result of decay of Th_{230}, the levels of Ra_{226} are expected to increase over time as noted in the NRC reports (NRC, 1982 and 1988). Table 1 summarizes the projected in-growth of Ra_{226} over time. The projected increase in Ra_{226} activity levels over time is graphically portrayed on Figure 2. The maximum Ra_{226} activity concentration will increase from more than 22,000 pCi/g to more than 800,000 pCi/g in approximately 1,000 years. The projected increase in Ra_{226} levels over time will result in both increased radiation levels and increased radon gas generation over time. The projected increase in radiation and radon levels over time were analyzed as part of the risk characterization included the Baseline Risk Assessment (Auxier & Associates, 2000).

Proposed SFS Revisions

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Subject to EPA approval of the evaluation and discussion presented above, this information will be incorporated into the characterization of the RIM, that as requested by EPA Additional Comment No. 15 will be presented in a revised Section 2 to the SFS.

References

Auxier & Associates, 2000, Draft Baseline Risk Assessment, West Lake Landfill Operable Unit 1, April.

Engineering Management Support, Inc. (EMSI), 2010 Supplemental Feasibility Study West Lake Landfill OU-1, DRAFT, July 23.

EMSI, 2006, Feasibility Study, West Lake Landfill Operable Unit – 1, Final, May, 8.

EMSI, 2000, Remedial Investigation Report, West Lake Landfill Operable Unit 1, April.

Radiation Management Corporation, 1981, Report on Site Visit – West Lake Landfill, St. Louis County, Missouri.

United States Environmental Protection Agency (USEPA), 2008, Record of Decision West Lake Landfill Site, Bridgeton, Missouri, Operable Unit 1, May.

USEPA, 1972, Sanitary Landfill Design and Operation, SW-287.

United States Nuclear Regulatory Commission (NRC), 1988, Radioactive Material in the West Lake Landfill, NUREG-1308 Rev. 1, June.

NRC, 1982, Radiological Survey of the West Lake Landfill, St. Louis County, Missouri, NUREG/CR-2722, May.

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EPA RESPONSE:

EPA does not approve of the evaluation and discussion presented above (i.e., pages 2 through 13, under "Discussion"). The objectionable portions are shown with ~~strikeout text~~ above and include gratuitous criticisms of the NRC's limited investigation.

For purposes of comparing the NRC and RI data for Areas 1 and 2, EPA recommends that the following text be incorporated into the new section of the SFS that would characterize the radiologically impacted materials (RIM), instead of the discussion and evaluation presented above (pages 2 through 13, under "Discussion"):

> Overall, the findings and conclusions of the remedial investigation (RI) about the location and nature of the radioactivity at West Lake Landfill are in agreement with those reported by contractors to the U.S. Nuclear Regulatory Commission in the 1980s (NRC 1988; RMC 1981). Both investigations identified approximately the same two areas (so-called Radiological Disposal Areas 1 and 2) where radiologically impacted materials (RIM) are present at the Site. Both studies found that the radioactivity at the Site results from occurrences of uranium and its decay products and is dominated by thorium-230 and radium-226. Both studies determined that the levels of radium-226 at the Site are not in radioactive equilibrium with the levels of thorium-230 and, consequently, the levels of radium-226 are anticipated to increase during the next few hundred years as a result of decay of thorium-230. Both studies determined that the then-existing and expected future concentrations of radionuclides are significantly elevated, relative to proposed cleanup levels. Both studies determined that the subsurface occurrences of RIM extend beyond the limits of the surface occurrences of RIM. Finally, both studies concluded that the majority of the RIM is located within approximately 15 feet of the ground surface. For example, RIM was identified during the RI in Area 1 at depths generally ranging between 0 and approximately six feet in the northwestern portion (see RI at page 92) and between 0 and approximately 15 feet in the southeastern portion (see RI, at page 92) and with an average thickness of approximately three feet (see RI, at page 93). RIM was identified during the RI in Area 2 at depths generally ranging between 0 and approximately six feet in both the northern portion (see RI at page 97) and southern portion (see RI, at page 92) and with an average thickness of approximately four feet (see RI, at page 98).

The foregoing concise narrative is consistent with the approach suggested by EPA during our meeting in Kansas City in September 2010. It may benefit from appropriate references to the calculations and graphical depictions in Appendix A of the draft SFS, dated July 2010. Additional documentation of these conclusions may be included in an additional appendix to the SFS and may include the yellow-highlighted discussion shown above (i.e., in pages 2 through 13, under "Discussion", with amendments shown in "Track Changes").

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EPA requests and expects that future revisions of the SFS be provided to us in the form of complete chapters, ideally in a sequence corresponding to the final document, as was requested during our meeting in Kansas City in September 2010.

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The increased radiation and radon gas emissions resulting from decay of Th_{230} over time were also addressed in the SFS report in conjunction with the description of the ROD-selected remedy. Specifically, the anticipated increase in radiation levels owing to increased Ra_{226} levels over time was addressed by ensuring that the new landfill cover was sufficiently thick so as to provide sufficient protection against the calculated levels of radiation resulting from in-growth of Ra_{226} over time (1,000 years) from Th_{230} decay. The increased levels of radon gas expected to occur as a result of in-growth of Ra_{226} over time (1,000 years) from Th_{230} decay were addressed during the SFS evaluations (EMSI, 2010) by increasing the thickness of the landfill cover under the ROD-selected remedy and the on-site disposal alternative. Specifically, to provide sufficient radon attenuation the thickness of the rock and clay layers were increased for the landfill cover over Area 2. The thickness of the landfill cover for the on-site disposal cell alternative was also developed to address radon attenuation.

RIM Configuration

Both the NRC and the RI investigations drilled soil borings, performed downhole gamma logging of the soil borings and collected soil samples for laboratory analyses. No soil boring logs were included or described in the NRC reports while generalized boring logs based on inspection of large diameter bucket auger cuttings were included in the RI. Downhole gamma logs are included in the RI but are not included in the NRC reports; however, the NRC reports do contain tabular summaries of the downhole gamma counts for each 1-ft depth interval logged. One or two soil samples were collected from each of the RI soil borings and submitted to an offsite laboratory for radiochemical analyses. The NRC studies utilized an in situ gamma measurement system consisting of an intrinsic germanium (IG) detector coupled to a multichannel analyzer to perform qualitative and quantitative field analyses during logging of the boreholes. Only eight surface soil samples (the locations of which are unspecified for most of the samples) and two borehole samples (sample depths unspecified) were collected and submitted for offsite radiochemical analyses as part of the NRC studies.

The results of the downhole gamma logging obtained by the NRC and RI studies from the generally, but not strictly, co-located soil borings were compared to assess the comparability of the data and potential variations in radionuclide activities in Areas 1 and 2. Review of the NRC and RI studies identified fifteen locations where NRC and RI soil borings were drilled in the same general areas. Table 2 presents a summary comparison of the results of downhole logging and soil sample activity levels developed by the NRC and RI investigations for soil borings located in approximately the same general locations.

For example, RI boring WL-112 was drilled in Area 1 approximately 80-ft to the northeast of NRC boring no. 38 (referred to in the RI as PVC-38 reflective of the existing of the PVC-casing installed by the NRC that was subsequently identified and located during the RI). Downhole logging performed during the RI identified a peak gamma reading of 10,000 counts per minute (cpm) at a depth of 6.5 ft below ground surface (bgs) in WL-112. Downhole logging performed by NRC in NRC boring no. 38 identified a peak gamma reading of 5,000 cpm at a depth of 7 ft bgs. Re-logging of NRC boring no. 38 was performed through the PVC casing during the RI. This re-logging identified a peak gamma reading of 17,000 cpm at a depth of 8 ft bgs. All of the

results of the gamma logging indicate the presence of radionuclides within the waste materials at a depth of approximately 6.5 to 8 ft bgs in the area of RI boring WL-112 and NRC boring no. 38.

Review of the data presented on Table 2 indicates that a high degree of variability exists in the locations and intensity of the radionuclide occurrences in Areas 1 and 2. Both investigations identified the presence of elevated gamma readings in many of the proximal boring locations, at similar depth intervals with similar activity levels (e.g., WL-112/PVC-38, WL-114/PVC-26, WL-117/PVC-36, WL-209/PVC-4, WL-209/PVC-7, and WL-226/PVC-19) and in one instance (WL-222/PVC-34) both studies identified the absence of elevated gamma levels in the same general area. In other instances, elevated gamma levels were not found to be present in an RI boring drilled near an NRC boring that identified the presence of a gamma peak (e.g., WL-115/PVC-25, WL-118/PVC-26, and WL-227/PVC-40) or elevated gamma readings were identified in an RI boring in one area (WL-113/PVC-27) where elevated gamma readings were not found by the NRC study.

A total of 27 of the NRC borings were re-logged as part of the RI study. Table 3 lists and compares the results for the peak (highest) gamma readings obtained during the NRC and RI studies. For the most part the re-logging of the NRC borings during the RI yielded similar results to those observed by the NRC study; however, there were a few exceptions. The RI re-logging identified a distinct gamma peak in NRC boring 10 (PVC-10) at a depth of 10 ft bgs that was not identified by the earlier NRC logging of this boring. Similarly, the RI re-logging of NRC boring 12 (PVC-12) identified a distinct peak at a depth of 2.5 ft bgs that was not identified by the earlier NRC logging of this boring. Conversely, the NRC results indicate the presence of a slight gamma peak at a depth of 5 ft bgs but the subsequent RI re-logging did not identify the presence of elevated gamma readings at this depth interval. In addition, the depths at which some of the peak values were identified at some locations varied (between 1 to 3 ft) between the two studies (e.g., NRC borings 5, 7, 9, 25,and 33).

Probably the biggest apparent difference between the two studies occurs between the narrative descriptions of the nature and distribution of the RIM occurrences presented in the two studies. Although as discussed above both studies identified the same two general areas and lateral extents of RIM occurrences and both studies found that the lateral extents of the subsurface occurrences of RIM were greater than the surface extent of RIM occurrences, the description of the nature and distribution of the RIM materials appears to be different.

First, in some instances the reported depths of the subsurface RIM occurrences differed between the two reports. The 1988 NRC report states that "Contaminated soil (>5 pCi Ra-226 per gram) is found from the surface to depths as great as 20 feet below the surface." Although generally correct, the NRC characterization of the depth of contamination is not strictly correct in all cases. NRC logging of boring no. 22 indicated elevated gamma readings (>50,000 cpm) and corresponding elevated radium-226 values (calculated values of 640 to 5,800 pCi./g) at depths of 23 to 25 ft bgs in this boring. The 25 ft depth was the maximum depth drilled so the actual vertical extent of contamination at this location cannot be determined from the available information. This boring was located in the southern portion of Area 2; however, this boring was not located during the RI field work. RI soil borings WL-233 and WL-235 were drilled near the area of NRC boring no. 22. Logging of WL-233 and WL-235 identified the presence of elevated

gamma readings with peak levels occurring at 22 and 22.5 ft bgs respectively. The NRC borings were drilled and logged to depths ranging from 21 to 39 ft bgs in Area 1 and 9 to 36 ft bgs in Area 2. The average depth of the ten NRC borings drilled and logged in Area 1 was 26.3 ft bgs while the average depth of the 30 NRC borings drilled and logged in Area 2 was 22.3 ft bgs. Nearly one fourth of the NRC borings (nine of the 39 borings drilled in areas 1 and 2) were drilled to depths of less than 20 ft bgs. All of these shallower borings were located in Area 2 where the RI identified the presence of deeper occurrences of RIM.

In contrast, the RI borings were drilled to depths of 15 to 105 ft bgs in Area 1 and 11 to 146 ft bgs in Area 2. Gamma logging of the RI borings was performed to depths ranging from 11 to 102 ft bgs in the Area 1 soil borings and 7 to 54.5 ft bgs in the Area 2 soil borings. The average depth of the twenty RI borings drilled and logged in Area 1 was 38 ft bgs while the average depth of the 34 RI borings drilled in Area 2 was 31 ft bgs. Based on both downhole gamma logging and/or analytical laboratory results, the RI identified a number of locations where contaminated materials were present at depths below 20 ft bgs extending to depths of as much as nearly 50 ft bgs at some locations.

As noted above, the NRC characterization of the radionuclide activity levels was primarily based on the results of the downhole logging and resultant calculated values for individual radionuclide activity levels. Only two subsurface soil samples (the depths of which were unspecified) were obtained by the NRC and submitted to an offsite laboratory for radiochemical analyses and neither of these samples were analyzed for Ra_{226}. In addition, Ra_{226} activity levels from soil borings drilled in Area 1 were not measured or calculated in the NRC study.

The maximum peak value for Ra_{226} activity reported on Table 5 of the NRC report was 440,000,000 (4.4×10^9) pCi/g for a sample obtained from the 18 ft depth from NRC boring no. 21 located in the southern portion of Area 2; however, this value appears to be incorrect and is not considered to be reliable as it is never discussed in the text of the NRC report and is inconsistent with the downhole gamma logging results obtained from this boring and depth interval. The next highest value presented on Table 5 of the NRC report is 22,000 pCi/g obtained from the 2-ft depth interval in NRC boring no. 1; however, the location of this boring is not provided on any of the figures in the 1982 or 1988 NRC reports. Given the lack of documentation regarding the values and locations of the two highest Ra_{226} results reported in the NRC study, the validity of these results is questionable. The next highest values reported on Table 5 of the NRC report are 15,000 pCi/g for the 1 ft depth sample in boring no. 3, 13,000 for the 2 ft depth interval in boring no. 11, and 11,000 pCi/g for the 15 ft depth sample in boring no. 16. These borings were located in the central and southern portions of Area 2. By comparison, the maximum reported Ra_{226} activity level reported by the analytical laboratory for the RI soil samples was 3,060 pCi/g found in the 10-ft depth sample obtained from boring WL-234 located in southern portion of Area 2.

The causes of the differences in the description of the depth of contamination between the NRC and RI reports include:

> Differences between the locations of many of the RI soil borings compared to the NRC soil borings;

Differences in the depth of the soil borings and/or the depth of gamma logging between the RI and NRC studies; and

General lack of laboratory analytical data from the NRC study, in particular almost no data (field or laboratory) for Th-230 (8 surface soil samples the locations for most of which are unspecified and two subsurface samples the depths of which are unspecified in the NRC study) compared to the extensive soil sample analytical results (over 120 sample were subjected to laboratory analyses, not counting background, duplicate, or Ford property samples, including 48 samples from Area 1 and 74 samples from Area 2) obtained as part of the RI.

The conceptual models of the nature and distribution of the RIM developed by the two studies also differ significantly. The 1988 NRC report states "In general, the contamination appears to be a continuous single layer ranging from 2 to 15 feet thick and covering 16 acres." It should be noted that although the NRC reported that "In general, the contamination appears to be a continuous single layer...", this characterization appears to be in conflict with the graphic characterization portrayed on Figure 14 of the NRC report. Review of this figure, including adjusting to account for the fact that the figure does not represent a true cross-section (i.e., the figure does not does not present the borings in order or directional sequence and does not post results for adjacent borings next to each other), indicates that there are large variations in both the activity levels and the elevations at which radionuclides were identified by the NRC in Areas 1 and 2.

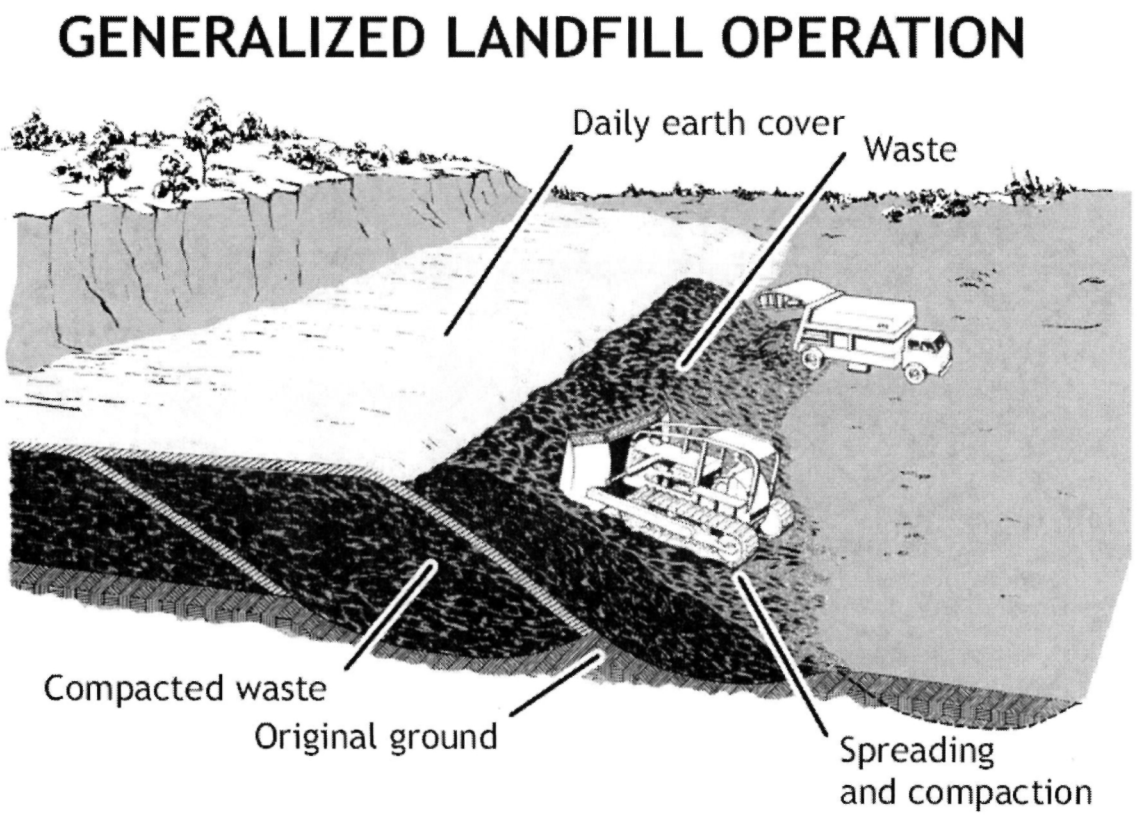
In contrast, the RI states "...the radiologically impacted materials present in Areas 1 and 2 are distributed throughout an overall matrix of solid waste materials including sanitary (household) wastes and construction and demolition debris." The RI goes on to state "Based upon observations of the cutting materials brought to the ground surface during the boring program, extensive discrete layers of soil, whether impacted or otherwise, were not identified." The RI also states "... a large portion of the radiologically impacted materials are present in the subsurface and occur in an interlayered and interspersed manner among the solid waste materials." The RI states further that "...occurrences of elevated downhole gamma readings as well as occurrence of radionuclides above reference levels or, even above background, were associated with a wide variety of solid waste materials containing varying amounts of soil."

The reasons for the reported differences in the conceptual understanding of the nature and distribution of the RIM developed by the two studies results from one or more of the following factors, (1) the nature and amount of the information collected and developed to describe the waste materials and contaminated soil, (2) consideration of landfill construction, operation and waste degradation processes, (3) the amount of time that elapsed between the two studies, and (4) variations in the intended degree of specificity or generality in the statements made regarding the conceptual distribution of the waste materials within the landfill.

No boring logs are included in the NRC reports and there is no indication that the materials encountered during drilling of the soil borings were logged or record during the NRC study. In contrast, the cuttings generated during drilling of the RI soil borings were described by a field

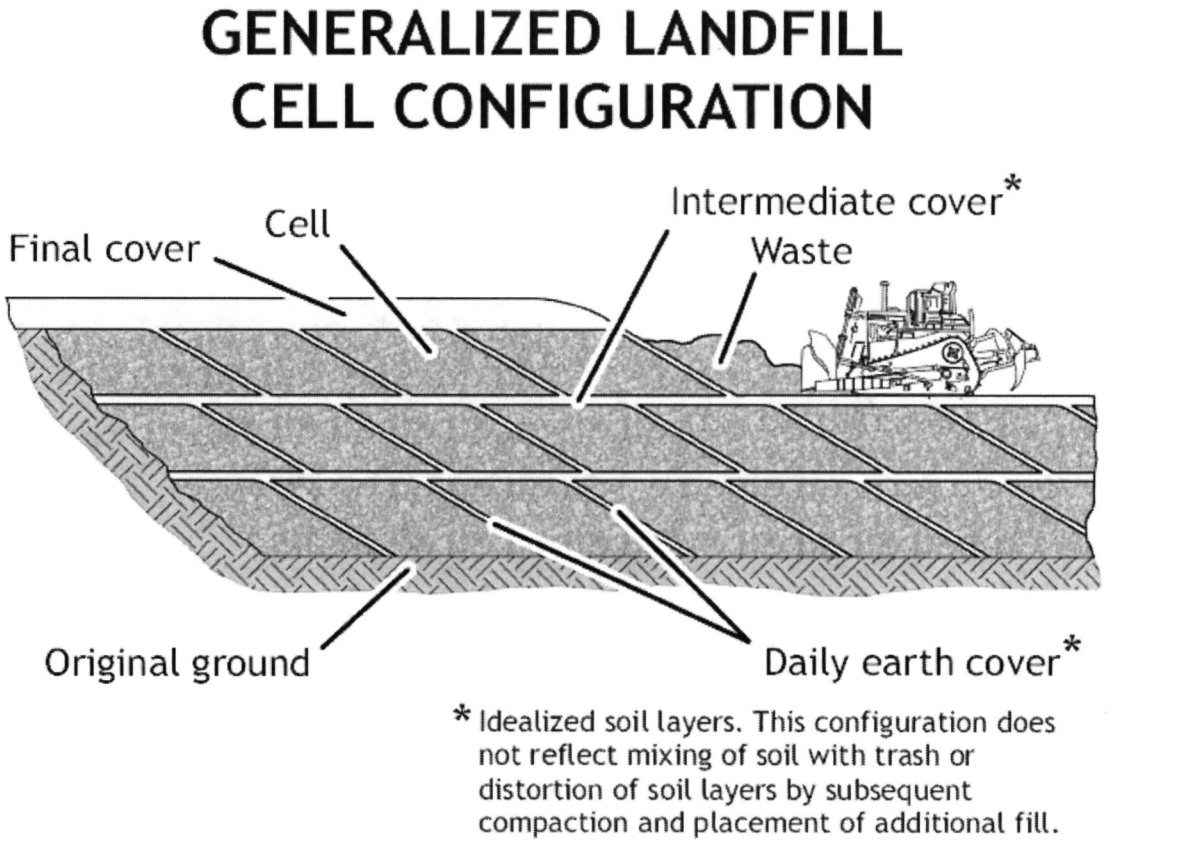
geologist and indicate that the soil material within the landfill does not occur in a discrete layer or layers but instead is interspersed within the overall matrix of landfill wastes.

Solid waste disposal units are not a single unit but instead are constructed and composed of numerous landfill cells. Each landfill cell is open and operated for a period of time (days, weeks, months or in some instances years) depending upon the size of the cell and the amount and rate of materials disposal at a site. Standard operating practice (EPA 1972), and since the 1970s and 1980s federal and state regulations, require placement of a thin layer of soil (currently 6-inches but minimum amounts were not specified prior to the 1970s and 1980s) over the waste materials at the end of each day of operations. Standard practice (EPA 1972) and later regulations required that areas in which landfill operations had been completed or that were not used for waste disposal for a period of six months or more be covered with an intermediate soil cover, generally consisting of approximately 12 inches of soil. Conceptual drawings illustrating landfill construction and operation activities that EPA presented during the public meetings for the site are presented below.



Construction of a solid waste landfill involves several processes that are specifically intended to, or indirectly result in redistribution of the waste materials, including any soil material used for daily or intermediate cover during landfill operations. These processes include the following: initial dumping of the waste in or near a waste disposal cell; spreading of the wastes within the disposal cell; compaction of the wastes within a disposal cell; placement of daily soil cover layer over the disposal cell; dumping, spreading and compaction of wastes in the overlying disposal cells; placement of daily cover on top of the overlying disposal cells; placement and compaction

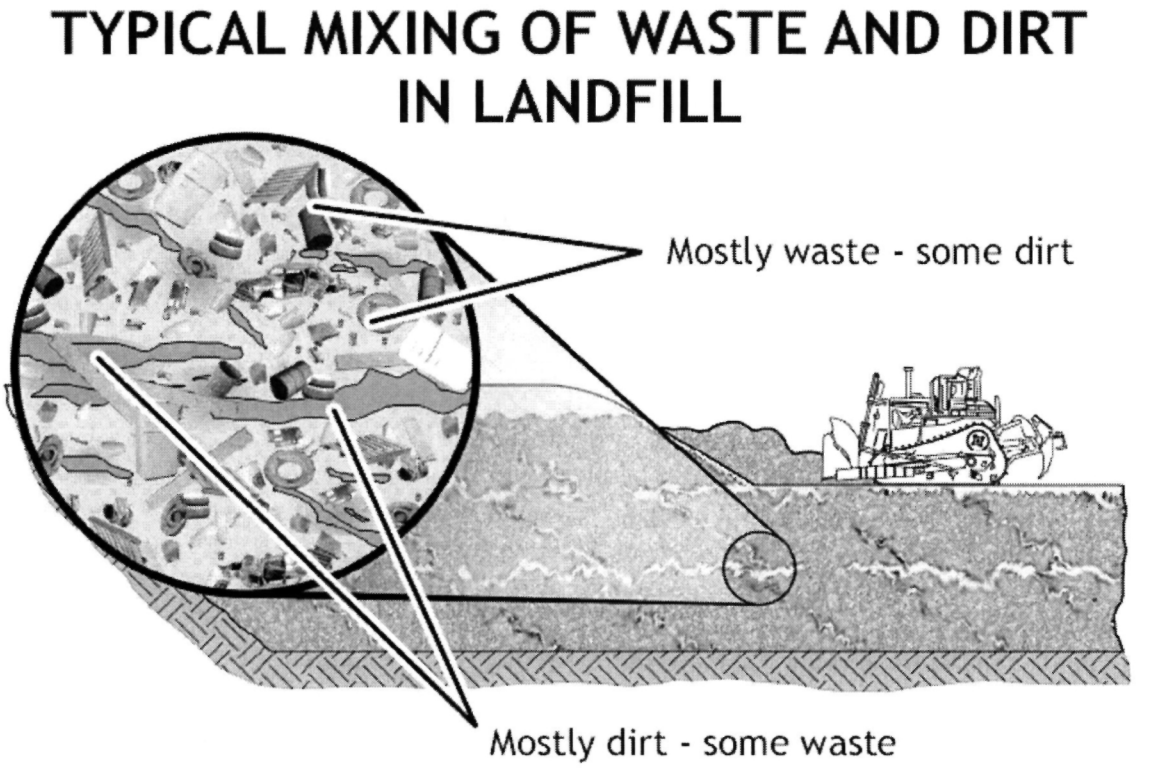
of intermediate soil cover layer over completed disposal cells; and placement and compaction of final soil cover and construction of the vegetation layer. As can be seen in the figure below, daily soil cover layers are not placed in uniform, horizontal layers. In most landfills, intermediate soil cover layers also tend to be non-horizontal as compaction of landfill wastes is best achieved by running compacting equipment up landfill slopes. Proper landfill operation calls for daily and intermediate soil cover to be applied to both the top and sideslopes as construction of a landfill cell progresses, with the intent of leaving only the working face exposed. Proper landfill operation calls for covering of the working face at the end of each day of operations. Construction of landfill cells in this manner results in non-uniform, non-horizontal layers where soil used as daily or intermediate cover is present within the landfill mass.



Solid waste materials do not compact equally. Large or more solid items such as construction and demolition debris, appliances, and other objects are subject to minimal compaction whereas household trash, yard trimmings, and other more putresible wastes are more easily compacted. Consequently, solid waste materials are subject to differential compaction through the operating life of a landfill. Differential compaction and other processes result in differential displacement of the waste materials and soil cover layers immediately upon and long after placement of these materials in the landfill cell. Thus, although a daily or intermediate soil layer may be placed over a landfill cell at one time, from the time it is initially placed and subsequently through time, such soil layers do not occur or remain as a discrete, identifiable, homogeneous, isolated layers

within a landfill but becomes mixed within the overall matrix of solid wastes disposed in the landfill.

Solid waste materials are also subject to microbial degradation, specifically anaerobic microbial degradation. It is the microbial degradation of the solid waste materials that results in generation of significant amounts of methane gas within solid waste landfills. It is well established that methane gas generation peaks within a few years after completion of landfilling and covering of a landfill and declines with time. Methane gas generation is a result of the overall microbial degradation which consequently is also more extensive during the initial years after closure of a landfill. Microbial degradation results in decomposition of the waste materials which in turn causes compaction and settlement of the waste materials. Due to variations in the waste composition, landfill construction, variations in the waste moisture content and contact with precipitation, and other factors, decomposition, compaction and settlement of landfill waste materials does not occur in a uniform manner but rather landfill wastes are subject to differential compaction and settlement. Differential compaction and settlement is a condition that occurs over time and results in changes to the vertical distribution of the waste materials and in particular the thin layers of daily and intermediate soil cover placed over the waste materials when active landfilling operations were being performed in Areas 1 and 2. The amount of differential compaction and settlement and thus the amount of disruption and displacement of the thin soil (landfill cover) layers within the landfill mass is expected to increase over time.



As a result of the processes initially conducted during construction of the landfill (i.e., waste dumping, spreading, compaction, placement of daily soil cover, construction of overlying waste cells, placement of intermediate soil cover, and construction of a final landfill cover as described above) combined with the effects of microbial degradation and resultant additional differential compaction and settlement, the initially placed irregular soil cover layers become further disrupted and dislocated within the overall landfill mass.

Sanitary landfill wastes also settle as a result of filtering of fines (e.g., soil or other fine material moving downward through the landfill mass in response to gravity of water flow). The weight of the landfilled wastes also causes compaction and differential settlement of the waste materials. Application of superimposed loads resulting from stockpiling of soil or other materials over completed, or interim portions of a landfill cause significant compaction and differential settlement. This is a significant factor for site such as the West Lake Landfill that was also used for stockpiling of sand and gravel and other materials. Placement of stockpiles over previously deposited wastes results in significant additional compaction beyond that achieved with landfill equipment alone. As the placement of stockpiled materials is not uniform over a landfill surface and changes with time and continued operations, the resultant differential compaction and settlement that occurs is highly variable.

Nearly fifteen years elapsed between the time the NRC field work was performed (1981) and the time the RI field investigations were conducted (1995). Although at most sites the passage of time would not be expected to significantly affect the distribution of contamination, this is not the case with a landfill site containing waste materials that are subject to microbial degradation, decomposition and differential compaction and settlement as described above. The NRC investigation was performed only a few years after Areas 1 and 2 had been closed and at a time when ongoing landfilling and sand and gravel extraction and stockpiling were still occurring. For example, the 1980 RMC report (RMC was the contractor that performed the work for the NRC study) states "The [site] visit had been delayed over one month due to ongoing landfill operations in the area of interest to RMC." This report further states "This estimate [of the areal extent of contamination] assumes that contamination extends under the existing stone and gravel piles, where readings could not be made."

There is also a question as to the degree of reliability or emphasis that should be placed on the NRC description of the nature and distribution of the RIM within Areas 1 and 2. The 1982 NRC report states "...the original volume of 40,000 tons has been diluted by a factor of about 4, which is not unexpected, with the continual movement and spreading of materials during filling operations." The NRC description of the distribution of the contaminated soil states "In general, the contamination appears to be a continuous single layer ranging from 2 to 15 feet thick and covering 16 acres." This statement begins with the qualifier "In general ..." without providing any description of the range of variability of the distribution of the waste materials or the degree of reliability subsequent readers should place on this sentence. The sentence could simply be intended to indicate that the contaminated soil is not randomly distributed within the landfill and not intended to provide a definite statement that the contaminated soil only occurs as an identifiable, homogeneous, discrete layer. Likely, this sentence was intended to indicate that the occurrences of elevated gamma readings reflective of the presence of contaminated soil were identified within specific depth intervals and not to imply that the contaminated soil itself occurs

in an isolated, discrete, homogeneous layer in Areas 1 and 2. This is supported by the statement presented in the 1988 NRC report "The manner of placing the 43,000 tons of contaminated soil in the landfill caused it to be mixed with additional soil and other material, so that now an appreciably large amount is involved." The uncertain nature of the NRC's description of the occurrences of contaminated soil within Areas 1 and 2 is further reflected by the uncertainty expressed by the NRC regarding the volume of contaminated soil when the 1988 NRC report goes on to state "If it [the contaminated soil] must be moved, it is not certain whether the amount requiring disposal elsewhere is as little as 60,000 tons or even more than 150,000 tons."